Peer Review Comments on:

Technical Background Document:
Mercury Wastes
Evaluation of Treatment of Bulk Elemental Mercury

and

Technical Background Document:
Mercury Wastes
Evaluation of Treatment of Mercury Surrogate Waste

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Submitted by:

Ishwar P. Murarka, Ph.D.
Chief Scientist, Ish Inc.

Submitted to:

Science Applications International Corporation
Engineering and Environmental Management Group
11251 Roger Bacon Drive
Reston, Virginia 20190

and

U.S. Environmental Protection Agency
Ariel Rios Building
Office of Solid Waste
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20460

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# Peer Review Comments on Two Mercury Treatability Studies by Ishwar P. Murarka, Ph.D. Chief Scientist, Ish Inc. (June 30, 2002)

The U.S. Environmental Protection Agency (U.S. EPA) and the U.S. Department of Energy have collaborated on a series of studies to evaluate effectiveness of treatment technologies for stabilization of wastes containing large amounts of mercury. As a result, two reports have been prepared by SAIC in 2002 which are being peer reviewed. These reports are entitled (1) "Evaluation of Treatment of Mercury Surrogate Waste", and (2) "Evaluation of Treatment of Bulk Elemental Mercury".

Ishwar Murarka of Ish Inc. was retained as one of the peer reviewers for these two reports. The peer reviewers have been charged to answer and fully explain their responses to the following questions:

(1) Was the experimental design of the study appropriate?

(2) Was the study conducted properly?

(3) Were the stated objectives adequately met?

The peer reviewers were also asked to provide additional information on the following general questions:

(1) Are you aware of any other data/studies that are relevant to the assessment of stabilized mercury-bearing wastes and the behavior of these wastes in the environment?

(2) With regard to the disposal of treated mercury wastes, are additional studies warranted for other factors that impact solubility or affect ability to leach, such as use of macroencapsulation? If you believe that additional studies are needed, please explain why.

(3) Do you agree that the following statements are supported by the research results?

a) Site-specific disposal conditions must be considered along with appropriate treatment technology as decisions are made about disposal of mercury wastes.

b) The presence of chloride ions in a given disposal environment may significantly impact the release from a treated waste form (mercury selenide).

Ish Inc. was provided with a CD containing the two final reports and a period of three weeks was allocated for completing the peer review. A hard copy and an electronic copy of the review comments were required from the peer reviewers.

The following write-up provides my review comments to answer each of the charge questions for each of the two reports.

## I. Comments and Response to Charge Questions on the Report Entitled "Evaluation of Treatment of Surrogate Wastes"

Charge Question 1: Was the experimental design of the study appropriate?

Answer 1: Yes. My review of the report and the accompanying appendices indicates that this study was conducted with clearly defined objectives and with careful designing and implementation of the testing details. This study was a controlled laboratory study that focused on creating a surrogate waste sludge covering multiple forms of mercury at high concentrations. This study focused on laboratory leaching tests to determine the effectiveness of treatment technologies that were tested. Sufficient replicates were utilized and a number of technologies were selected and tested in the study in an appropriate manner.

Charge Question 2: Was the study conducted properly?

Answer 2. Yes. My review of the SAIC (2000) report indicates that all vendors and laboratories properly carried out the surrogate sample preparation, and the leaching tests on the prepared treated surrogate waste samples. All characterization data appears to be properly collected and reported.

Charge Question 3: Were the stated objectives adequately met?

Answer 3. Yes, for the most part. The study objectives as stated in the report dealt with (1) an evaluation of alternative stabilization process by examining the TCLP test results to meet a goal of 0.025 mg/L or less, and (2) to compare proposed new leaching test protocols to the standard TCLP results. The study also included leach testing of pellets and crushed forms of the stabilized wastes. Fixed pH leach tests were replicated only part of the time.

The results and graphs presented in the report clearly indicate that leachate concentrations derived from the stabilized waste are always significantly lower than those obtained from the un-stabilized waste. The results presented also show that there are significant differences in the effectiveness of the various treatment technologies that were tested. The results further show that the constant pH leaching test results depict a pH dependent leaching behavior of mercury. Based

on this one surrogate waste testing results, it also appears that Vendor A technology performs the best except when the stabilized waste is exposed to very alkaline condition (i.e., pH >11.0). Vendor B stabilized waste seems to meet the 0.025 mg/L goal only for the very alkaline condition, and Vendor C stabilized waste meets the leachate goal of 0.025 at pH greater than 9. The Vendor D stabilized waste meets the 0.025 mg/L goal only at pH greater than 10.

Therefore, this report should conclude that all treatment technologies that were tested are not equally effective, and that Vendor A technology provides the most treatment effectiveness for a much broader range of pH conditions than the other three vendors. This report should also recognize that the new leaching test protocols yield significantly different results than TCLP test. This is not surprising in light of the fact that TCLP test was developed to simulate a mismanagement case of waste disposal in a municipal landfill, whereas the constant pH-leaching test covers a broad range of environmental conditions for leaching.

A couple of editorial suggestions are added here for the summary tables in the report. Tables containing analytical results on TCLP for the various vendors (e.g., Table 5-3) should be better labeled to show which are pelletized samples, which are crushed samples, and which ones are untreated samples.

Additional Information Questions and Answers.

Question 1. Are you aware of any other data/studies that are relevant to the assessment of stabilized mercury-bearing wastes and the behavior of these wastes in the environment?

Answer 1. No, I am not aware of any other data/studies that are similar in nature to this study.

Question 2. With regard to the disposal of treated mercury wastes, are additional studies warranted for other factors that impact solubility or affect ability to leach, such as use of macroencapsulation? If you believe that additional studies are needed, please explain why?

Answer 2. Yes. This study was conducted by preparing and evaluating a surrogate waste sample. However, no data/results have been generated to show that stabilization and leaching characteristics of actual wastes would yield similar results when tested in a similar manner. I suggest that two or more wastes containing over 260 mg/Kg of mercury be subjected to stabilization and leaching by TCLP as well as by the constant pH leaching protocols. If those test results show that leachates do not exceed 0.025 mg/L goal at all pH values then selection of stabilization technology would not require any site-specific considerations.

Question 3. Do you agree that the following statements are supported by the research results?

> (a)Site-specific disposal conditions must be considered along with appropriate treatment technology as decisions are made about disposal of mercury wastes.

Answer 3(a). I partially agree. As indicated in my response to the foregoing Question 2, the answer to this question is that it depends on the results obtained from carrying out the recommended testing of actual wastes. However, based on the results presented in this report, it seems that pH was the only environmental parameter tested for the evaluation of effectiveness. The Vendor A technology will require that the site be evaluate to determine if the leaching fluid that will be infiltrating through the stabilized waste has a pH of 10 or less. No other disposal conditions would need to be considered. In my technical evaluation of the test results presented in the report, I see that Vendor A technology should be used because of its effectiveness under a large range of pH conditions.

## II. Comments & Response to Charge Questions on the Report Entitled "Evaluation of Treatment of Bulk Elemental Mercury"

Charge Question 1. Was the experimental design of the study appropriate?

Answer 1. Yes. This study was conducted with well-defined objectives and a carefully generated study design. The test protocols and operating instructions were well developed. This study conducted controlled laboratory testing of elemental mercury stabilization offered by commercially available methods and vendors. The stabilized samples were tested for leaching in the laboratory in a replicated manner.

Charge Question 2. Was the study conducted properly?

Answer 2. Most likely yes, although there are possible heterogeneity present in the stabilized wastes as indicated by large variability in concentrations in replicates subjected to leaching tests. My review of the material in the report suggests that the vendors and laboratories properly carried out the preparation of stabilized waste forms and the leaching tests required on the stabilized samples. Appropriate QA/QC and reporting of results have been accomplished.

Charge Question 3. Were the stated objectives adequately met?

Answer 3. Yes. The report specifies two major objectives as (1) to evaluate alternative treatment processes for elemental mercury to meet a TCLP treatment goal of 0.025 mg/L or less, and (2) to empirically test and compare new leaching protocols to the standard TCLP method. This study included testing of pellets and crushed samples of the stabilized/treated elemental mercury. In addition, limited evaluation was conducted to examine the effects of chloride in leaching solution on leaching of mercury from stabilized materials.

The results and graphs presented in this report clearly show that there are significant differences in the effectiveness of the various treatment technologies. The constant pH leaching test results indicate that leaching of mercury from the stabilized elemental mercury is a pH dependent phenomenon. For example, Vendor B stabilized material shows a monotonic increase in mercury leaching as the leaching fluid pH is increased

from highly acidic to highly alkaline. Vendor C stabilized elemental mercury shows a decreasing leaching pattern when leaching fluid pH is increased from acidic pH of 2. The Vendor A results are more variable.

The leaching test results indicate that Vendor B treatment performs the best and meets the treatment goal of 0.025 mg/L leachate concentration for pH range of 2 to at least 10. The Vendor C stabilized material does not yield results that are 0.025 mg/L and/or lower. Vendor A does produce stabilized material that meets the leaching goal only at pH 2.

Therefore, this study report should recognize that all treatment technologies that were tested are not equally effective, and that Vendor B technology provides the most effective method for a large range of pH conditions. This report also needs to conclude that the new leaching test protocols yield significantly different leaching concentrations than the TCLP test. This is not surprising, particularly when elemental mercury is being reacted to form a sulfide solid phase compound that is known to have pH dependent solubility.

Additional Information Questions and Answers.

Question 1. Are you aware of any other data/studies that are relevant to the assessment of stabilized mercury-bearing wastes and the behavior of these wastes in the environment?

Answer 1. No, I am not aware of any other data/studies pertinent to this study.

Question 2. With regard to the disposal of treated mercury wastes, are additional studies warranted for other factors that impact solubility or affect ability to leach, such as use of macroencapsulation? If you believe that additional studies are needed, please explain why?

Answer 2. No. This study has achieved the goals of the project and has generated scientifically sound results. This study does show that there is at least one treatment technology that should be effective over a large range of leaching fluid pH. If, however, there are additional technologies that emerge then similar testing is desirable to evaluate the expected effectiveness of the new technology.

Question 3. Do you agree that the following statements are supported by the research results?

(a)Site-specific disposal conditions must be considered along with appropriate treatment technology as decisions are made about disposal of mercury wastes.

Answer 3(a). Based on the review of the results reported, it seems that pH was the only environmental parameter tested. For the Vendor B technology it appears that disposal sites with leaching fluid of greater than pH 10 should be avoided for disposing the stabilized wastes and all other sites below pH 10 will be appropriate for disposing of stabilized waste. Therefore, I believe that statement in (a) as written is more stringent than supported by the research results and should be therefore modified.

Question 3(b). The presence of chloride ions in a given disposal environment may significantly impact the release from a treated waste form (mercury selenide).

Answer 3(b). The limited data developed and presented in this report do support the statement in (b). However, it would be desirable to generate empirical results using a number of chloride concentrations in leaching fluid to establish correlation between chloride concentrations and leachability of mercury converted to mercuric selenide. These experiments will provide a basis for deriving the lower limit of chloride concentration that should not be exceeded in the leaching fluids.